Amplitude and latency of EEG Beta activity during real movements, discrete and continuous motor imageries

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Motivation

Motor imagery (MI) modifies the neural activity within the primary sensorimotor areas of the cortex in a similar way to a real movement [1]. More precisely, beta oscillations (18-25 Hz), which are often considered as a sensorimotor rhythm, show that the amplitude of brain oscillations is modulated before, during and after a MI. Before a MI, compared to a resting state, there is a gradual decrease of power in the beta band of the electroencephalographic signal, called event-related desynchronization (ERD). Moreover, from 300 to 500 milliseconds after the end of the MI there is an increase of power called event-related-synchronization (ERS), or post-movement beta rebound, with a duration of approximately one second [2]. A large number of Brain-Computer Interfaces (BCIs) are based on the detection of MI in the electroencephalographic signal [3]. In most MI-based BCI experimental paradigms, subjects realize continuous MI, i.e. a prolonged intention of movement, during a time window of a few seconds with the objective to increase the detection of ERD and ERS. However, when the subjects imagine a succession of movements, several ERD and ERS are generated, with lower amplitudes than those elicited by a single MI [4]. Here, we employ a simple short MI to detect the ERD and the ERS.

Material

- 11 right-handed subjects performing three tasks: a real movement, a discrete (or short) motor imagery and a continuous (or 4s-) motor imagery of an isometric flexion movement of the right hand index finger (fig. 1).
- 9 channels (FC3, FCz, FC4, CP3, Cz, C4, CP3, CPz, CP4) sampled at 256 Hz.
- 3 sessions of 4 runs each containing 100 trials per session (Fig 2).

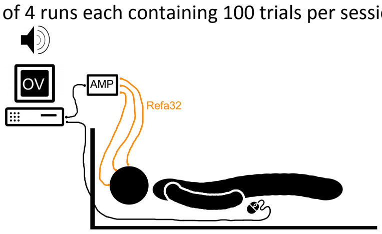

Fig. 1. Schematic representation of the experiment. A low frequency beep indicates the start of the (real or imagined) movement. A high frequency beep indicates the end of the continuous imagined movement. Nine electrodes collect electrical potentials. A Refa EEG acquisition system (AMP) amplifies the signals. The OpenViBE software (OV) records the digitalized potentials.

Methods

- Here the ERD/ERS% is the oscillatory power estimated with respect to the power of the resting period 30 seconds before the each runs. It is computed every 125 ms for a 2-second window, for all channels separately.

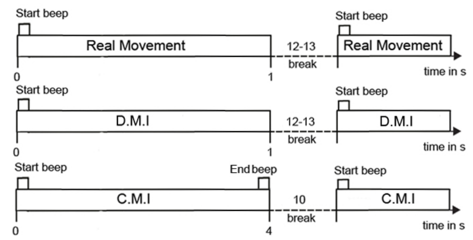

Fig. 2. Timing schemes of a trial for each task: Real Movement (top); Discrete Motor Imagery (middle); Continuous Motor Imagery (bottom).

Results

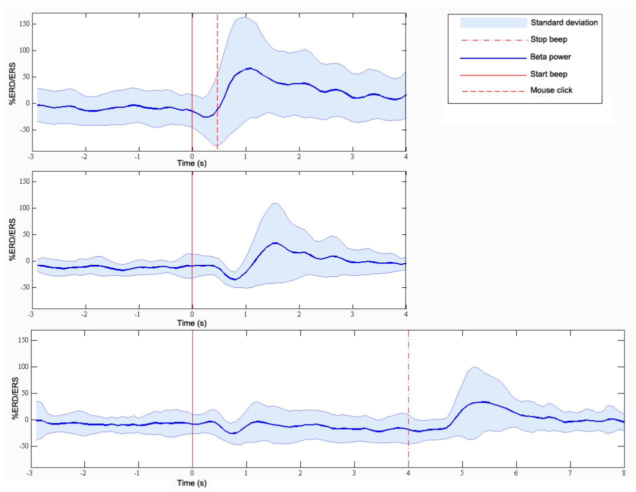

Fig. 3. Grand average (n = 11) ERD/ERS% curves estimated for the real movement (top), the discrete motor imagery (middle) and the continuous motor imagery (bottom) within the beta band for electrode C3.

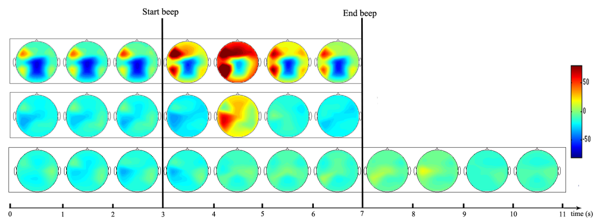

Fig. 4. Topographic map of ERD/ERS% of subject 4 in the beta band during real movement, (top) DMI (middle) and CMI (bottom). Red corresponds to a very strong ERS (+70%) and blue to a very strong ERD (-70%).

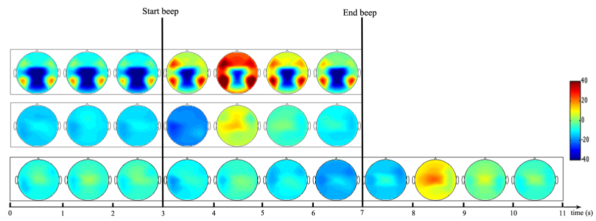

Fig. 5. Topographic map of ERD/ERS% (grand average, n=11) in the beta band during real movement, (top) DMI (middle) and CMI (bottom). Red corresponds to a strong ERS (+40%) and blue to a strong ERD (-40%).

Conclusion

The results suggest that both discrete and continuous MIs modulate ERD and ERS components.

The ERS is very similar in both cases, but the ERD generated by a discrete MI is easier to detect due to its higher power (35 *ERD*/*ERS*%) and lower variability (σ = 25 *ERD*/*ERS*%). Moreover, continuous MIs generate a later ERS, as well as a more variable (σ = 50 *ERD*/*ERS*%) and less detectable ERD (15 *ERD*/*ERS*%). These results show that discrete motor imageries may be preferable for BCI systems design in order to reduce users fatigue and to decrease the response time.

References

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